



## Brief article

# Social eye gaze modulates processing of speech and co-speech gesture



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## ABSTRACT

In human face-to-face communication, language comprehension is a multi-modal, situated activity. However, little is known about how we combine information from different modalities during comprehension, and how perceived communicative intentions, often signaled through visual signals, influence this process. We explored this question by simulating a multi-party communication context in which a speaker alternated her gaze between two recipients. Participants viewed speech-only or speech + gesture object-related messages when being addressed (direct gaze) or unaddressed (gaze averted to other participant). They were then asked to choose which of two object images matched the speaker's preceding message. Unaddressed recipients responded significantly more slowly than addressees for speech-only utterances. However, perceiving the same speech accompanied by gestures sped unaddressed recipients up to a level identical to that of addressees. That is, when unaddressed recipients' speech processing suffers, gestures can enhance the comprehension of a speaker's message. We discuss our findings with respect to two hypotheses attempting to account for how social eye gaze may modulate multi-modal language comprehension.

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## 1. Introduction

Face-to-face communication is a multi-modal activity often involving multiple participants. Despite this, language comprehension has typically been investigated in uni-modal (i.e., just speech) and solitary (i.e., one listener) contexts. Here, we investigate language comprehension in the context of two other modalities omnipresent during face-to-face communication, co-speech gesture and eye

gaze. Moreover, we explore the interplay of these modalities during comprehension in a dynamic context, where a speaker's eye gaze switches between two interlocutors, rendering them sometimes directly addressed, and sometimes relatively unaddressed, a typical characteristic of multi-party conversation.

Despite the uni-modal focus of traditional approaches to language comprehension, recent years have seen an increase in studies considering language as consisting of both speech and co-speech gestures. These studies have provided behavioural and neural evidence that co-speech gestures are processed semantically and integrated with speech during comprehension (e.g., [Holle & Gunter, 2007](#);

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Kelly, Kravitz, & Hopkins, 2004; Kelly, Özyürek, & Maris, 2010; Willems, Özyürek, & Hagoort, 2007, 2009; Özyürek, Willems, Kita, & Hagoort, 2007; Wu & Coulson, 2005, 2007; Yap, So, Melvin Yap, Tan, & Teoh, 2011). Research has further shown that this integration process is not always automatic but sensitive to the perceived intentional coupling of gesture and speech—such as when observing a gesture performed by one person accompanying speech produced by another (Kelly, Creigh, & Bartolotti, 2010; Kelly, Ward, Creigh, & Bartolotti, 2007). A question that remains is whether the processing of multi-modal utterances is also modulated by social cues integral to the communicative situation, such as when a speaker's gaze conveys information about whom he/she is addressing.

Due to the saliency of the sclera in the human eye in contrast to other primate species, gaze is a powerful social cue in human interaction (e.g., Goodwin, 1981; Kendon, 1967; Rossano, 2012; Senju & Johnson, 2009). While some studies have investigated speech-gesture comprehension in the presence of gaze, they have done so without manipulating gaze direction as an independent cue (e.g., Kelly et al., 2004; Straube, Green, Jansen, Chatterjee, & Kircher, 2010; Wu & Coulson, 2007a).

One exception is a recent study (Holler, Kelly, Hagoort, & Özyürek, 2012) in which a speaker alternated her gaze between two recipients, rendering one of them addressed and the other unaddressed during each message she communicated. This study focused on how the manipulation of social gaze would influence the comprehension of uni-modal (“she trained the horse”) and bi-modal (“she trained the horse” + whipping gesture) utterances. Following each utterance, participants saw a target word onscreen, matching either the preceding speech (speech-related targets [e.g., to train]) or the preceding gesture conveying complementary information (gesture-related targets [e.g., to whip]). Unaddressed recipients responded more slowly than addressees to gesture-related target lures following the bi-modal utterances. However, their response times for the uni-modal (speech-only) conditions did not differ from those of addressees (neither for the speech- nor the gesture-related targets). Participants in this study were required to focus their attention on the verbal modality, firstly, by making judgements about the *speech* they heard in the preceding video, and, secondly, by responding to *verbal* targets displayed onscreen. Explicitly focusing participants' attention on speech in this way might simply not be suitable for uncovering processing differences relating to the speech modality.

The present study uses a visually focused paradigm that avoided explicit attention to the preceding speech, or to words onscreen, to allow us to better observe potential differences in addressed and unaddressed recipients' processing of bi-modal messages (speech + gesture) and the processing of speech when speech is the only modality carrying semantic information. Like Holler et al. (2012), we simulated a triadic communication setting. Participants watched a speaker who was filmed in such a way that she appeared to be looking either at them or at another recipient, conveying speech-only or speech + gesture utterances referring to objects (e.g., “he prefers the laptop”). The gestures depicted a typical feature of the object mentioned

(e.g., a typing gesture). Each message was followed by two object pictures and participants indicated which of these matched the preceding message as a whole. Thus, instead of probing participants' processing of *either* the speech-related or the gesture-related utterance components (Holler et al., 2012), the present study assesses comprehension of the message *overall* rather than probing its separate components.

We have two hypotheses regarding the influence of social eye gaze on multi-modal (speech + gesture) message comprehension. The *Parallel Attenuation Hypothesis* states that social eye gaze direction affects the processing of information in the speech and gesture modalities in a parallel fashion. Schober and Clark (1989) have shown that overhearers process speech less well than addressees in contexts without visual access to the speaker. In contexts that do provide such visual access, gaze direction is an important indicator of communicative intent. Semantic information provided by a speaker who averts her gaze to look at someone else may thus be perceived as intended for this other person. In face-to-face communication, unaddressed recipients may thus not only process speech less well than addressees, but their processing of co-speech gestures may be attenuated, too. If this hypothesis holds, we would expect overall message comprehension (i.e., including speech + gesture utterances) to be less efficient for unaddressed than for addressed recipients.

Alternatively, the *Cross-modal Enhancement Hypothesis* states that social eye gaze direction influences the processing of speech and gesture differently: When unaddressed recipients' speech processing suffers, gesture does not. This effect may be due to the fact that, when the speaker's eye gaze is averted, gesture is still available for/directed at the unaddressed recipient (since, in triadic communication, speakers tend to produce gestures in front of their body visually accessible for all participants, Özyürek, 2002). Access to gestural information might thus enhance unaddressed recipients' speech comprehension, resulting in addressed and unaddressed recipients comprehending the overall message equally well.

The present study aims to tease apart which of these hypotheses may best explain how, in the context of gaze-directional addressing (Lerner, 2003), recipients comprehend multi-modal language in a pragmatically richer context than has been investigated traditionally.

## 2. Method

### 2.1. Participants

32 right-handed, native German speakers (16 female) from Rostock University (tested at the Max Planck Institute for Demographic Research in Rostock) participated in the experiment (mean age 24.5 yrs) and were financially compensated (€10).

### 2.2. Design

We used a 2 × 2 within-participants factorial design, manipulating gaze direction of the speaker (direct gaze/

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